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# Has the COVID-19 pandemic changed food waste perception and behavior? Evidence from Italian consumers

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ABSTRACT

Food waste represents a multi-sectoral issue and influences the economy, society and environment. Considering that over 50% of food waste is generated from household consumption, the issue has been included among the 17 Sustainable Development Goals, with the aim of halving its quantity by 2030. However, the COVID-19 pandemic imposed several variations in the agri-food industry in terms of food manufacturing, storage and distribution, changing at the same time food access, food consumption and food waste behavior. The present paper, through an online-based questionnaire among 831 respondents from Italy and the application of the cumulative logit model, investigates consumer behavior after the lockdown with reference to unpredictable lifestyles, improvements in smart food delivery and never-experienced time management. Results illustrate that *always-at-home* consumers (forced to stay at home 24 h a day) are more likely to perceive food waste and reduce its amount, whereas discontinuous smart working makes food purchase, preparation and consumption activities even more stressful and complex. Furthermore, smart food delivery tends to increase consumers' awareness of meals, improving buying decisions and indirectly reducing food waste generation. The unjustifiable prevalence of household food waste represents a major barrier to the achievement of food security, health insurance and hunger reduction, but also the most promising entry point to stress in the achievement of private and public benefits. Thus, the active role of education among young generations must be enhanced.

## 1. Introduction

Food waste represents a multi-sectoral issue and produces significant impacts on the economy, society and environment all over the world [1,2]. Indeed, each year more than 1.3 billion tons of food, equal to approximately one-third of global food production, is wasted along the whole food supply chain [3,4]; [101]. Under financial, social and environmental perspective on global scale, full costs associated to food waste have been assessed in approximately USD 1 trillion per year, to which environmental costs (USD 700 billion) and social costs (USD 900 billion) must be added [5], while food waste carbon footprint has been estimated in over 3.3 Gigatons (Gt) of $CO_2e$ each year (6% of global GHG emissions) [5–7]. In the European Union (EU), more than 140 million tons (Mt) of food is wasted each year [8] of which approximately 24% is from harvesting and post-harvesting production, 23% from industrial transformation, 5% at the distribution level, 9% from food service and 39% from households [9,10], estimated in over 140 billion euros in terms of financial costs [11], less than 520 million MJ in terms of nutritional losses [12] and over 170 Mt of $CO_{2eq}$ (3% of global EU emissions) released in the atmosphere [13]. In Italy, food waste is estimated at approximately 8.5 Mt per year, resulting in loss in over 15 billion euros and roughly 8.5–14.5 Mt of $CO_{2eq}$ [14].

To reduce food waste impacts and address economic, environmental and societal concerns, impressive initiatives have been adopted in the field of resource use efficiency, reduction of supply chain disruptions, food donations and food waste valorization [15]. At the international level, the United Nations has included food waste among the 17 Sustainable Development Goals (SDGs), pursuing the challenge of reducing hunger and enhancing responsible consumption and production [16,17]. The main aim is to halve per capita global food waste at retail and consumer level, as well as to reduce food losses along agricultural, post-harvest and manufacturing stages by 2030. At the EU level, as a consequence of the adoption of *Closing the loop – An EU action plan for the Circular Economy* [18], the monitoring framework for the circular

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economy has included food waste among the 10 circular economy indicators [19,20]. Furthermore, through the adoption of the *Farm to Fork Strategy* (part of the European Green Deal), the EU imposed on the entire community actions for sustainable food consumption and food loss and waste prevention. The latter highlights the opportunities coming from the implementation of such actions for agri-food operators and final consumers [21], such as the general improvement of economic development, food safety, food security and climate change. Indeed, although upstream stages of the food supply chain (harvesting and post-harvesting, industrial manufacturing) should be monitored, the EU focuses on food waste occurring through retail, food service and household consumption (downstream stages) [1], where roughly 70 Mt of food is wasted each year [22]. The unjustifiable prevalence of food waste in households represents a major barrier to the achievement of food security, health insurance and hunger reduction, but also the most promising entry point to stress in the achievement of private and public benefits [23,24].

Nowadays, the COVID-19 pandemic still represents a social, health and financial challenge all over the world, affecting all economic and industrial sectors, significantly the agri-food industry in terms of food manufacturing and consumption [25,26]. Worldwide, the World Health Organization [27] confirmed more than 120 million cases and over 2.6 million deaths (18$^{th}$ March 2021), of which European ones amount to over 34%. In Italy, more than 3.2 million cases and approximately 103, 000 deaths have been registered (18$^{th}$ March 2021). In terms of socio-economic consequences, from March 2020 onwards, entire countries adopted different forms of *social distancing* with the aim of limiting disease infection diffusion. This lockdown period upset life, work and food consumption habits among households [28,29]. People, forced to stay at home (24 h a day) or experiencing smart working, had enough time to discover food planning and food storage techniques, adopt food diets, increase time assigned for eating, improve cooking skills and familiarize themselves with food domestic appliances. Moreover, the fear of not finding enough food (resources) in the medium-long term played a significant role in changing domestic habits [30].

In the light of these premises, this paper investigates current attitudes, awareness and behavioral patterns related to food waste reduction in domestic consumption during the COVID-19 pandemic. Through an online-based questionnaire and applying the cumulative logit model (CLM) to analyze data, the authors investigate Italian consumer behavior following the COVID-19 lockdown with reference to unpredictable lifestyles, improvements in smart food delivery and never-experienced time management. The originality of this paper lies in the investigation of food waste perception and behavior through a hypothesis approach, based on a series of variables such as employment status, smart working experience, smart food delivery, food diets and sport activities, useful to identify and propose new paths for sustainable food consumption at home.

## 2. Literature review: consumer behavior and effects of the pandemic

The role of households in the reduction of food waste is crucial [31,32]. In recent decades, a plethora of studies have focused on food waste issue determinants, measurement and opportunities. Despite one of the first analyses conducted on the issue dating back to 1974 [33] and the first waste definition being presented in 1975 [34], the vast majority of studies have followed the publication of the first report on food loss and waste assessment along the food supply chain in 2011 [1]. The most recent studies in the field of household food consumption/waste investigated general drivers and barriers to food waste reduction [35,36], as well as particular domestic practices to reduce its amount (e.g., food preparation planning, improvement of storage conditions) [37,38]. Furthermore, some authors have analyzed how to address international policies [39] and intervention programs [24], identifying in leftover management, education campaigns and date-labelling awareness some of the key points to emphasize [40], but only a few have stressed the unavoidable link between environmental impacts (e.g., resource depletion, greenhouse gas emissions) and food waste [41,42].

In terms of households' food waste behavior, some studies have analyzed individual and potential variables associated with the issue [43,44], recognizing a set of behavioral patterns (e.g., purchasing attitude, consumer perception) that could enhance food waste management at home [45–47]. However, even if the role of households' food waste in times of crisis has been under-researched before the pandemic [48], numerous studies have analyzed households' behavioral changes induced by the COVID-19 all around the world. At first glance, all authors highlighted an almost homogeneous behavior among consumers, either in European [30,49,50], American [51,52], Asian [53,54] or African [55,56] realities, estimating effects almost comparable between countries. According to Ben Hassen et al. [55], consumers shifted toward healthier diets, increasing domestic products consumption and changing modality of acquiring food toward online shopping. Indeed, Alaimo et al. [49] and Laguna et al. [50] examined the significant role of online food shopping during the pandemic in Italy and Spain, while either Jribi et al. [56] or Roe et al. [52] stressed the need to improve households' skills and management practices to reduce the day-to-day food waste both in Tunisia and America. Further, Brizi and Biraglia [53] investigated the gender role and the psychological variables correlated with stockpiling and food waste processes in India, while Shi et al. [54] emphasized the role of food safety knowledge toward sustainable food consumption behaviors among Chinese consumers.

## 3. Methodology

In line with the Commission Delegated Decision (EU) 2019/1597 of May 3, 2019 [57], which states that "the amount of food waste within a stage of the food supply chain shall be established by measuring food waste generated by a sample of households in accordance with any of the following methods or a combination of those methods or any other method equivalent in terms of relevance, representativeness and reliability," the authors adopted the questionnaire methodology to analyze food waste behavior among households. As Møller et al. [9] stated, questionnaires are structured and formal ways to collect quantitative or qualitative data among all actors of the agri-food sector, from producers to consumers, and are cost effective, usually standardized, accessible and easy to read. The questionnaire-based analysis conducted in the present study followed systematic steps: (1) literature analysis on the Web of Science (WoS) Core Collection; (2) hypothesis development and questionnaire drafting; (3) sampling strategy and data collection; and (4) statistical approach and data analysis. Furthermore, considering the food waste definition as one of the main criticalities in food waste studies, the authors adopted that proposed by FAO [58]: food waste is the "the masses of food lost or wasted in the part of food chains leading to edible products going to human consumption," referring to food originally destined for human nutrition but later discarded or reused for other purposes [59].

### 3.1. Literature background on food waste questionnaire-based studies

To begin the analysis and gain a better understanding of domestic food consumption and wastage, the authors conducted a brief but comprehensive literature review on food waste questionnaire-based studies using the WoS Core Collection. In the last five years (2015–2020), several authors have successfully applied questionnaires, in all forms (by e-mail, by telephone, electronically or in person), in food waste studies. In the downstream stages, Willersinn et al. [60] applied a standardized 8-page questionnaire sent by e-mail to investigate the potato supply chain in Switzerland, Hartikainen et al. [61] utilized 21 different questionnaires to analyze primary production in Nordic countries, and Baker et al. [62] conducted in-depth interviews to understand primary production in Northern and Central California. In the

upstream stages, some authors have measured food waste quantities in food services [63,64] and the hospitality sector [65], while others have investigated household behavior and major food waste drivers [66,67], as well as food waste quantities [68]. However, even though one study has already detected the effects of the lockdown on food waste during the COVID-19 pandemic [30], none has analyzed attitudes, awareness and behavioral patterns of domestic food waste with reference to the role of smart working, time management and smart food delivery.

### 3.2. Hypothesis development

The drafting of a clear and logical questionnaire (wording, clarity, interpretation) was based on three main pillars: a) the use of an investigative technique that avoids distribution of the object investigated; b) the elaboration of simple questions to speed up participation during compilation; and c) the use of direct questions to avoid excessive space for participants' and researchers' interpretations [69]. Thus, to pursue the overall aim of the study and test the weight of selected household variables on food waste generation, the authors developed the following hypotheses:

**Hypothesis 1.** ($H_1$): Sociodemographic variables (age, gender, job, financial status, education, household size) and employment status have a direct effect on food waste perception (FWP) and food waste behavior (FWB).

**Hypothesis 2.** ($H_2$): Smart working (from 14th October to 14$^{th}$ November 2020) has a direct effect on FWP and FWB.

**Hypothesis 3.** ($H_3$): Smart food delivery (from 14th October to 14$^{th}$ November 2020) has a direct effect on FWP and FWB.

**Hypothesis 4.** ($H_4$): Food diets (voluntary or mandatory) and sport activities have a direct effect on FWP and FWB.

Fig. 1 illustrates the extended hypothesis development.

In terms of FWP, the authors investigated the impact (positive or negative) of selected items (e.g., sociodemographic variables, smart working, smart delivery, food diets and sport activities) on households' social and environmental awareness of food waste issues. In terms of FWB, the authors examined the impact of the abovementioned items on the self-reported quantities of food waste in seven food categories: fruit, vegetables, rice and pasta, meat and meat-based products, fish and fish-based products, milk and dairy products, bread and baked products, and prepared meals (including takeout and delivered food) [59]. Participants' reported quantities referred to the month prior to the compilation (from 14th October to 14$^{th}$ November 2020).

### 3.3. Questionnaire drafting, sampling strategy and data collection

The questionnaire (available on demand) consisted of 29 single-option queries divided among four sections: a) sociodemographic characteristics (ten questions); b) general shopping habits in the last month (four questions); c) time management and domestic activities in the last month (eight questions); and d) food consumption and food wastage in the last month (seven questions). To increase the significance of qualitative and quantitative information, the authors added to dichotomous questions (yes or no) also 7-point Likert scale questions, because they appear to be more suited to electronic distribution and offer more accurate records of participants' evaluations [70,71]. As discussed by Joshi et al. [72], the 7-point Likert scale (from *not at all* to *very much*) provides more varieties of options which could increase the probability of meeting the objective reality of people, offering more independence to respondents and allowing them to pick the exact option rather the closest one [73].

The questionnaire was written in Italian and realized in Google Forms, an online platform useful to create questionnaires, receive fast answers and analyze data in multimodal formats [74,75]. The questionnaire link was disseminated online from 14$^{th}$ November 2020 to 30$^{th}$ November 2020 on social media (e.g., Instagram, LinkedIn, Facebook) and distributed via e-mail. Participants were asked to sincerely respond to a questionnaire on household food waste and share the survey as much as possible. Due to the restrictions imposed by the health emergency, but still in line with previous literature [30,76], the distribution of the questionnaire link followed the non-probabilistic snowball method. Indeed, as discussed by Cohen and Ariely [77], the snowball sampling represents a widely applied method in Internet research, either guaranteeing security under pandemic conditions or reaching as many respondents as possible requiring the minimal planning and human resources [49]. However, being a nonrandom technique, it does not guarantee representation and is vulnerable to sampling biases (e.g., risk of self-selection, internal and external validity limitations). Nevertheless, the large number of participants (n = 831) overcame such a limit.

All respondents were asked to consent to data processing only for academic purposes.

### 3.4. Statistical approach and data analysis

To select the most suitable statistical method to analyze collected data, the authors preliminarily conducted an explorative analysis using descriptive statistical tools (e.g., box plots, bar plots, scatter plots). Second, the authors applied the CLM. The model, initially introduced by McCullagh [78], is suitable to analyze response variables on an ordinal scale, for which the stochastic ordering can be defined using the distribution function [79]. Considering $Y_i$ as the random variable that describes the response of the *ith* subject in an ordered manner, with qualitative response variables on an ordinal scale, it is possible to define the following equation [1]:

$$\Pr(Y_i \leq j) = \pi_{i1} + \ldots + \pi_{ij} \quad \text{with } j = 1, \ldots, c \text{ and } \pi_{ij} = \Pr(Y_i = j) \qquad [1]$$

Cumulative logit is the logit transformation of the cumulative

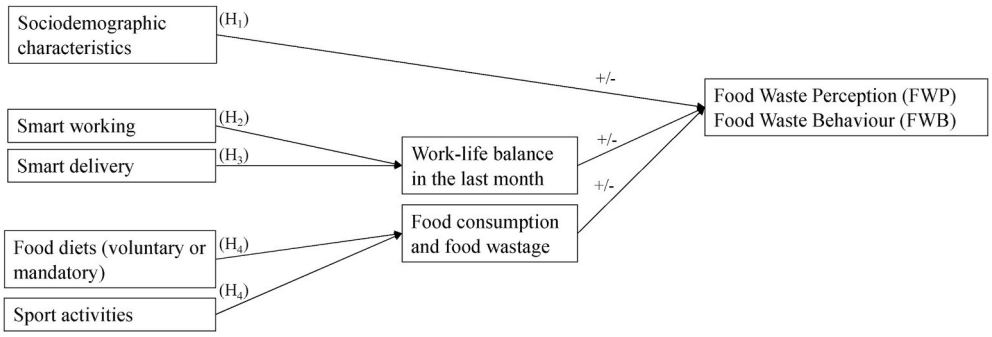


**Fig. 1.** Extended hypothesis development and study design
(Source: Personal elaboration by the authors).

probability, according to the following equation [2]:

$$logit\,[Pr(Y_i \le j)] = \log \frac{Pr(Y_i \le j)}{1 - (Y_i \le j)} = \log \frac{\pi_{i1} + \ldots + \pi_{ij}}{\pi_{ij+1} + \ldots + \pi_{ic}}. \quad [2]$$

with $j = 1, \ldots, c-1$

Thus, the applied CLM can be defined as follows [3]:

$$logit\,[\Pr(Y_i \le j)] = \alpha_i + x_i\beta \quad [3]$$

with $j = 1, \ldots c-1$ and $\alpha_1 \le \alpha_2 \le \ldots \le \alpha_{c-1}$

The parameters $\alpha_j$ represent intercept parameters, while the vector $\beta$ contains the regression coefficients with respect to the further covariates.

In order to choose the most suitable exploratory variables (covariates), the authors applied the stepwise approach [80] and created three different models: the first one enclosing all variables; the others, though considering the four hypotheses, deleting the less significant variables from time to time on the basis of coefficients p-value, consistency and adherence to the topic [81]. To compare the three models, the authors calculated the Akaike information criterion (AIC) [82] to measure their statistical quality. The authors used a 5% level of statistical significance, illustrating the p-value of variables in all tables. Data were processed using R 3.6.3 software (https://www.r-project.org).

## 4. Results

### 4.1. Sample characteristics

The sample was composed of 831 respondents from Italy (Table 1). In line with several studies [30,76], the majority of respondents were females (69.8%), while men represented a slighter quota (30.2%). The ratio is justified because women are still traditionally the main ones responsible for home management, family care and culinary activities [83,84]. In terms of age, respondents were heterogeneously distributed, with higher percentages of young people between 18 and 25 (24.1%) and adults between 46 and 55 years old (21.4%). The majority of households were made up of 4 or more people (43.1%).

Regarding smart working, participants were asked to answer based on their experience following the COVID-19 lockdown (Q10. *Due to the COVID-19 pandemic, have you experienced smart working or smart studying?*). Approximately 65% of respondents answered affirmatively. Of those, roughly 44% had performed half smart working on a monthly basis, approximately 27% less than half and more than 27% engaged completely in smart working. Overall, these values are almost in line with Italian trends [85], which have estimated that, on average, approximately 37% of workers were able to work from home in last quarter of 2020, with the highest peak at the beginning of the pandemic (47%).

The explorative analysis through descriptive statistical tools (e.g., box plots, bar plots, scatter plots) highlighted the reverse effect in the field of FWP and FWB with reference to employment situations and smart working experience (Table 2).

### 4.2. Food waste perception cumulative logit model results

The CLM is suitable for the analysis of ordinal response data, considering at the same time the ranked order inherent in ordinal response data, the adjustment of confounding variables and the assessment of effect modification on a modest sample size [86]. As previously stated, the authors applied the stepwise approach and created three different models. The first model included all variables related to sociodemographic characteristics (i.e., gender, age, civil status, households composition, region and province of residence, residence area in terms of size, education, financial status, employment situation), general shopping habits (i.e., price care, food purchase frequency, food purchase place, food delivery), time management and domestic activities (i.e., smart working experience, average smart working hours, sport activities) and food consumption and wastage behavior (i.e., mandatory and voluntary recycling, mandatory and voluntary diet, environmental issues care, food waste apps knowledge, change in food waste perception after the COVID-19 lock down). On the basis of coefficients p-value, consistency and adherence to the topic, the covariates were reduced in the passage from the first to the second model, and from the second to the third, until the elimination of some variables (i.e., age, civil status, region and province of residence and education). Further, the AIC has been calculated to compare the models, highlighting the following results: (a) first model = 1191.045; (b) second model = 1183.84; (c) third model = 1176.094. Therefore, the authors have selected the third one.

**Table 1**
Sociodemographic characteristics of the sample.

| Sociodemographic characteristics | Categories | Percentage (%) |
|---|---|---|
| Gender | Female | 69.8 |
| | Male | 30.2 |
| Civil status | Single | 48.5 |
| | Married | 43.2 |
| | Divorced | 6.5 |
| | Widower | 1.8 |
| Age | 18–25 | 24.1 |
| | 26–35 | 20.9 |
| | 36–45 | 15.6 |
| | 46–55 | 21.4 |
| | 56–65 | 11.4 |
| | Over 65 | 6.7 |
| Households composition | 1 | 9.9 |
| | 2 | 25.6 |
| | 3 | 21.5 |
| | 4 or more | 43.1 |
| Residence area | Big city (over 100,000 inhabitants) | 50.8 |
| | Small city (10,000–100,000 inhabitants) | 34.4 |
| | Town (fewer than 10,000 inhabitants) | 14.8 |
| Education | Elementary school | 0.6 |
| | Middle school | 3.5 |
| | Diploma | 39.5 |
| | Bachelor's or master's degree | 42.1 |
| | Master, Ph.D. | 14.3 |
| Financial status | Hard | 4.2 |
| | Humble | 29.8 |
| | Good | 61 |
| | Excellent | 5 |
| Employment situation | Employed | 56.5 |
| | Unemployed | 8.1 |
| | Housemaker | 5.3 |
| | Retired | 7.4 |
| | Student | 22.8 |
| Smart working experience | Yes | 64.9 |
| | No | 35.1 |

(Source: Personal elaboration by the authors).

The FWP-CLM response variable was ordered on a 7-point Likert scale and regarded sensitivity and perception toward food waste in light of the COVID-19 pandemic (Q25. *How sensitive are you to food waste?*). Table 3 illustrates the main FWP-CLM results. The groups of covariates are related to sociodemographic variables ($H_1$), smart working experience ($H_2$), food purchase frequency and habits, smart delivery ($H_3$), food diets and sport activities ($H_4$), general attitudes toward food waste and environmental issues, food waste app knowledge (e.g., ToGoodToGo) and individual perception of changes in food consumption following the COVID-19 lockdown.

In terms of sociodemographic variables, employment status ($H_1$) was estimated as a significant variable. Unemployed people are more likely to perceive food waste consequences (estimate: 1.2343, p-value: 0.0484), as are students (estimate: 1.8048, p-value: 0.0024). In general, individuals from such categories are between 18 and 35 years old, thus

**Table 2**
Employment situations, smart working experience and food waste.

| Employment status | FWP | | | | FWB | | | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | (a) | (b) | (c) | (d) | (a) | (b) | (c) | (d) | |
| Housemaker | 3 | 5 | 11 | 25 | 21 | 18 | 3 | 2 | 44 |
| Unenployed | 9 | 18 | 13 | 27 | 22 | 26 | 15 | 4 | 67 |
| Employed | 64 | 64 | 154 | 187 | 186 | 220 | 46 | 17 | 469 |
| Retired | 1 | 3 | 17 | 40 | 39 | 21 | 1 | 0 | 61 |
| Student | 43 | 45 | 52 | 50 | 43 | 102 | 12 | 33 | 190 |
| Smart working experience | FWP | | | | FWB | | | | Total |
| | (a) | (b) | (c) | (d) | (a) | (b) | (c) | (d) | |
| Never | 38 | 42 | 76 | 117 | 117 | 115 | 33 | 8 | 273 |
| <50% | 23 | 29 | 39 | 62 | 49 | 72 | 18 | 14 | 153 |
| >50% | 42 | 43 | 74 | 88 | 87 | 101 | 37 | 22 | 247 |
| Always | 21 | 24 | 56 | 57 | 51 | 83 | 15 | 9 | 158 |

(a) Not at all, to a small extent, to some extent; (b) To a moderate extent; (c) To a significant extent; (d) To a large extent, very much.
(Source: Personal elaboration by the authors).

belonging to younger generations compared with older ones.

Furthermore, smart working experience ($H_2$) revealed its significance in terms of FWP. Based on exploratory studies [87], the authors believed that a novel work-life balance would cause additional food waste at final consumption. Considering an average monthly basis of smart working, the authors assessed that people working from home for less than 50% of their work are less likely to perceive food waste (estimate: −1.6342, p-value: 0.0320), while their sensitivity slightly increases if smart working increases to more than 50% (estimate: −1.5935, p-value: 0.347). The lack of organization, not-always-precise work scheduling and professional stress due to the pandemic have potentially diverted workers' attention from food waste issues [88]. On the contrary, people experiencing smart working all day long revealed a greater awareness of food waste (estimate: 1.6624, p-value: 0.0302), demonstrating how stability and time management at home help individuals to consider consumption and waste consequences.

Considering food purchasing habits, the authors estimated that people buying huge quantities of food at greater/discounted prices (*price care*) are more likely not to consider food waste issue (estimate: −0.8221, p-value: 0.0011). Moreover, consumers whose food purchase frequency ranges between 2 or 3 days a week are more aware of food waste (estimate: 0.5806, p-value:0.0047). In general, food purchase place revealed no significance in terms of FWP.

In terms of food delivery ($H_3$), the FWP-CLM highlighted that consumers using smart delivery (e.g., apps) 2 or 3 days a week are more likely to be aware of food waste issues (estimate: 1.2423, p-value: 0.00004), especially in light of the fact that home delivery food is highly portioned and more expensive compared with raw ingredients [89].

Lastly, according to $H_4$ (food diets and sport activities), the authors estimated that consumers adopting a voluntary diet are less likely to perceive food waste (estimate: −0.5506, p-value: 0.0078), in line with previous studies on the topic [90].

Furthermore, participants were asked to declare their awareness of food waste environmental issues (Q27. *Are you aware of food waste environmental consequences, such as water or energy consumption and greenhouse gas emission?*). The application of the FWP-CLM to the dichotomic answer (yes or no) showed that consumers living in small towns with fewer than 10,000 inhabitants are less likely to understand food waste environmental consequences (estimate: −1.8361, p-value: 0.0434), while those adopting a mandatory healthier diet (estimate: 1.4197, p-value: 0.0917) and buying food through food waste-reduction apps (estimate: 2.0481, p-value: 0.0002) are more likely to understand food waste environmental issues.

### 4.3. Food waste behavior cumulative logit model results

The FWB-CLM response variable was ordered on a 7-point Likert scale (from *not at all* to *very much*) and regarded self-reported quantities of food waste for seven food categories (fruit, vegetables, rice and pasta, meat and meat-based products, fish and fish-based products, milk and dairy products, bread and baked products, prepared meals) in the last month. Participants were asked to assess food waste quantities (Q28. *How much food do you think you have wasted on average in the last month?*). Because each category was positively correlated with another, the authors assumed similar food waste behaviors among food categories. Fig. 2 illustrates results according to Kendall rank correlation coefficient.

It is estimated that all food commodities are positively correlated, above all fruits and vegetables (0.67), rice, pasta, meat and meat-based products (0.66), as well as meat, meat-based products, fish and fish-products (0.78). Being pasta one of the most representative staple food in the Mediterranean diet [91], its correlation is on average over 0.50 with all food commodities (excluded fruits and vegetables). Considering that the study did not aim to quantify food waste but to qualify participants' behavior, the authors applied the FWB-CLM to the average reported waste in each category.

Table 4 illustrates the main FWB-CLM results. It is important to highlight that the FWB-CLM applies the same variables as the FWP-CLM. Basically, the two models behave in opposite ways (an increase in FWP-CLM corresponds to a decrease in FWB-CLM), with only a few exceptions.

In terms of sociodemographic variables, employment status ($H_1$) represents a significant item. In fact, unemployed consumers tend to waste less food (estimate: −2.1337, p-value: 0.0017) than do employed individuals (estimate: −1.1212, p-value: 0.0713), as well as students (estimate: −2.0883, p-value: 0.0012). The FWB-CLM confirms the FWP-CLM results, because those who perceive food waste the most are the same as those who declared a lower quantity of food waste. Considering the smart working experience ($H_2$), no significant results were associated with food waste self-assessment, nor with food diets and sport activities ($H_3$).

In terms of organic recycling, the authors assessed that consumers voluntarily adopting a separate waste collection are more likely to waste lower amounts of food (estimate: −0.6517, p-value: 0.0514) compared with those who are forced (estimate: 0.6521, p-value: 0.0329).

The most interesting result of the FWB-CLM is regarding the ordinal responses related to participants' change in food consumption following the COVID-19 lockdown. Even though FWP did not immediately change due to the pandemic—cognitive control is a process that unfolds over time [92]—food waste behavior did. Indeed, all consumers reporting a change in food consumption during the pandemic are more likely to waste less food, as shown by those who declared a moderate change (estimate: −1.6609, p-value: 0.00000101) and a large one (estimate: −1.5975, p-value: 0.0001). Basically, unpredictable lifestyles changed consumers' behaviors faster than their perceptions.

**Table 3**
Food waste perception cumulative logit model (FWP-CLM).

| Food Waste Perception Cumulative Logit Model (FWP-CLM) | | | | |
|---|---|---|---|---|
| Coefficients | | Estimate | P-value | Significance |
| Gender | Ref. Male | 0.2327 | 0.2627 | |
| Residence area | Small city (10,000–100,000 inhabitants) | 0.0564 | 0.8118 | |
| | Town (fewer than 10,000 inhabitants) | 0.1437 | 0.6734 | |
| Financial status | Humble | 0.0150 | 0.9798 | |
| | Good | 0.0221 | 0.9695 | |
| | Excellent | −1.1096 | 0.1134 | |
| Employment situation | Unemployed | 1.2343 | 0.0484 | * |
| | Employed | 0.7058 | 0.2159 | |
| | Retired | 0.1945 | 0.8270 | |
| | Student | 1.8048 | 0.0024 | ** |
| Smart working experience | Yes | 1.1266 | 0.1220 | |
| Smart working (average) | Less than 50% | −1.6342 | 0.0320 | * |
| | More than 50% | −1.5935 | 0.0347 | * |
| | Always | 1.6624 | 0.0302 | * |
| Price care (ratio quantity/price) | Yes | −0.8221 | 0.0011 | ** |
| Food purchase frequency | 2-3 times a week | 0.5806 | 0.0047 | ** |
| | 4-5 times a week | −0.3906 | 0.3843 | |
| | Every day | 0.2091 | 0.6409 | |
| Food purchase place | Local market | −1.6688 | 0.0150 | * |
| | Retail shop (e.g., bakery, butchery) | −0.1613 | 0.6527 | |
| | Supermarket | −0.0224 | 0.9368 | |
| | Online | 0.1460 | 0.8765 | |
| Food delivery | 2-3 times a week | 1.2423 | 0.00004 | *** |
| | 4-5 times a week | −0.2596 | 0.7653 | |
| | Every day | 1.2046 | 0.5235 | |
| Recycling | Voluntary organic recycling | −0.5936 | 0.0578 | . |
| | Mandatory organic recycling | −0.4539 | 0.1181 | |
| Food diet | Voluntary | −0.5506 | 0.0078 | ** |
| | Mandatory | −0.3124 | 0.2365 | |
| Sport activities | Yes | 0.0520 | 0.7934 | |
| Environmental issues care | Yes | −1.6423 | 0.00003 | *** |
| Food waste apps knowledge | Yes | −0.1984 | 0.3259 | |
| Change in food consumption after the Covid-19 lock down | Not at all | 0.5334 | 0.0924 | . |
| | To a small extent | 0.6618 | 0.0464 | * |
| | To some extent | 0.3653 | 0.2632 | |
| | To a moderate extent | 0.0122 | 0.9704 | |
| | To a significant extent | −0.0848 | 0.8339 | |
| | To a large extent | −1.2413 | 0.83391 | |

Significance at 0 (***). Significance at 0.001 (**). Significance at 0.01 (*). Significance at 0.05 (.).
(Source: Personal elaboration by the authors).

## 5. Discussions

In light of previous results and considering that possible effects of the COVID-19 pandemic on FWP and FWB have been difficult to predict, the following key concepts can be discussed. First, the authors estimated that sociodemographic variables in general and employment status in particular have a significant impact on FWP and FWB, confirming $H_1$ as an interesting point of reflection. Moreover, smart working and smart delivery, contextualized in a novel and unpredictable work-life balance ($H_2$, $H_3$), defined new horizons, paths and reflections on domestic food waste. In addition, variables such as food diets (voluntary or mandatory) and sport activities ($H_4$) were analyzed, demonstrating a slight significance toward food waste awareness. It has been demonstrated that changes in food consumption (e.g., food purchase planning, storage operations, increased time allotted for eating, improved cooking skills,

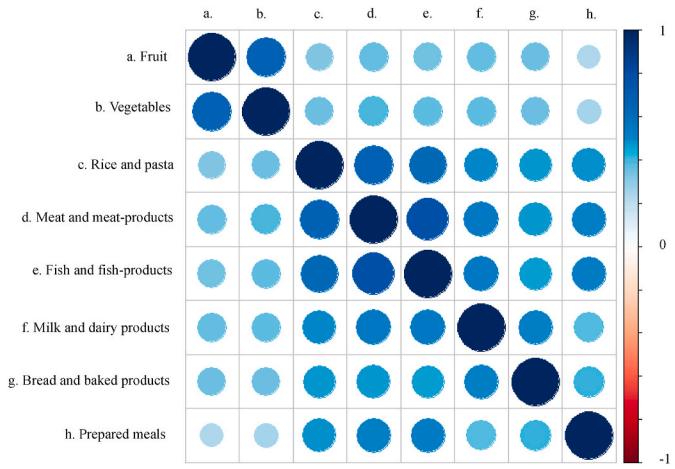


**Fig. 2.** Correlation between eight food categories
(Source: Personal elaboration by the authors).

familiarity with domestic appliances) due to the COVID-19 pandemic directly modified FWB, reducing on average the self-assessed quantities of food waste. Indeed, even if not yet metabolized, the fear of reduced medium-to long-term food availability led consumers to preserve resources and manage them in a more sustainable way, thus unexpectedly reducing food waste. Table 5 synthesizes FWP and FWB effects with regards to hypothesis development and variables significance.

It is necessary to proceed step by step. The results reveal a high likelihood of young generations of students (18–25 years old) and unemployed people (up to 45 years old) to reduce food waste. Indeed, both unemployed and students registered a sharp perception toward food waste issues, as well as a strong inclination toward its reduction. Among others, individuals from these categories were forced to stay at home during the COVID-19 lockdown and represent one of the few examples of *always-at-home* consumers (24 h a day). The accessibility of novel time management had a positive effect in the field of food waste reduction. Consumers could improve food purchase programming, storage operations and eating choices, showing the importance of time management during households' operations. People who spent more time at home, with the chance to plan culinary and food activities, tended to improve their perception of food waste and reduce, on average, its quantity. However, these circumstances were registered only among people spending all their time at home, whereas they are not valid for those who engaged in smart working part time (more or less 50%). Contrary to what was assumed, smart working activities made family management and food purchase, preparation and consumption operations even more stressful and complex, thus leading to increased food waste. Not surprisingly, consumers who carried out discontinuous smart working reported a lower perception of food waste, demonstrating their lack of time to plan and establish food habits.

Furthermore, the results highlight that price care in terms of quantity/price ratio and smart food delivery have significant effects on consumers' attitudes. Consumers more interested in buying discounted products (e.g., products on offer, family-size packages) and consumers affected by compulsive shopping, on average, show a low perception of food waste, displaying an unwise and inattentive attitude toward grocery shopping [93]. The key factor is simply buying too much food, especially during the pandemic, where the fear of not finding foodstuff rules. Home delivery, especially through digital apps (e.g., Deliveroo, Just Eat, Uber Eats) and social tools (e.g., Telegram), is relevant in the field of food waste perception, in particular among people ordering food 2 or 3 times a week. In line with previous studies [94,95], smart food delivery tends to increase consumers' awareness of products and improve buying decisions, thus reducing unappreciated meals, especially through high-definition photographs and precise food

**Table 4**
Food waste behavior cumulative logit model (FWB-CLM).

| Food Waste Behavior Cumulative Logit Model (FWB-CLM) | | | | |
|---|---|---|---|---|
| Coefficients | | Estimate | P-value | Significance |
| Gender | Ref. Male | −0.4244 | 0.0528 | . |
| Residence area | Small city (10,000–100,000 inhabitants) | −0.2261 | 0.3618 | |
| | Town (fewer than 10,000 inhabitants) | −0.4062 | 0.2593 | |
| Financial status | Humble | −0.1098 | 0.7357 | |
| | Good | −0.0451 | 0.9408 | |
| | Excellent | −0.2302 | 0.7502 | |
| Employment situation | Unemployed | −2.1337 | 0.0017 | ** |
| | Employed | −1.1212 | 0.0713 | . |
| | Retired | −0.4261 | 0.6523 | |
| | Student | −2.0883 | 0.0012 | ** |
| Smart working experience | Yes | 0.4686 | 0.5439 | |
| Smart working (average) | Less than 50% | −0.6166 | 0.4426 | |
| | More than 50% | −0.5856 | 0.4632 | |
| | Always | −0.3352 | 0.6784 | |
| Price care (ratio quantity/price) | Yes | 0.2541 | 0.3350 | |
| Food purchase frequency | 2-3 times a week | −0.3520 | 0.1015 | |
| | 4-5 times a week | −0.7263 | 0.1068 | |
| | Every day | −0.0546 | 0.9063 | |
| Food purchase place | Local market | 1.5492 | 0.0288 | * |
| | Retail shop (e.g., bakery, butchery) | 0.4500 | 0.2346 | |
| | Supermarket | 0.4559 | 0.1273 | |
| | Online | 0.2989 | 0.7658 | |
| Food delivery | 2-3 times a week | −0.5087 | 0.1059 | |
| | 4-5 times a week | −0.9457 | 0.2832 | |
| | Every day | −1.1521 | 0.5466 | |
| Recycling | Voluntary organic recycling | −0.6517 | 0.0514 | . |
| | Mandatory organic recycling | 0.6521 | 0.0329 | * |
| Food diet | Voluntary | −0.0756 | 0.7272 | |
| | Mandatory | −0.0644 | 0.8119 | |
| Sport activities | Yes | 0.2787 | 0.1811 | |
| Environmental issues care | Yes | −0.1091 | 0.7971 | |
| Food waste apps knowledge | Yes | 0.0094 | 0.9643 | |
| Change in food consumption after Covid-19 lock down | Not at all | −0.5253 | 0.1249 | |
| | To a small extent | −1.802 | 7.48e-07 | *** |
| | To some extent | −1.7332 | 1.01e-06 | *** |
| | To a moderate extent | −1.6609 | 3.20e-06 | *** |
| | To a significant extent | −1.5975 | 0.0001 | *** |
| | To a large extent | −0.6151 | 0.1516 | |

Significance at 0 (***). Significance at 0.001 (**). Significance at 0.01 (*). Significance at 0.05 (.).
(Source: Personal elaboration by the authors).

descriptions. Furthermore, the higher cost of food represents a crucial variable toward food waste reduction. It is a strong assumption, but if food is valued more, then its importance will probably increase.

An irrational element of reflection concerns the adoption of food diets, both voluntary and mandatory.

Food diets, generally including intrinsic shopping and portion size planning, should determine a higher perception of food waste, although the contrary has been estimated. These results necessitate further attention regarding the opportunity of transmission of food waste contents among people adopting diets. In the field of organic recycling, the authors assessed that people adopting mandatory separate collection still do not exhibit sustainable behavior in terms of food waste. Thus, it would be advisable to educate them to adopt more virtuous consumption behaviors.

**Table 5**
Effects on FWP and FWB according to hypothesis development.

| Hypothesis | Independent variable | Effect on FWP | Effect on FWB |
|---|---|---|---|
| $H_1$ | Unemployment | Yes (+) | Yes (−) |
| | Student status | Yes (+) | Yes (−) |
| $H_2$ | Smart working (<50%) | No | N/S |
| | Smart working (>50%) | Slight (+) | N/S |
| | Smart working (always) | Yes (+) | N/S |
| $H_3$ | Smart food delivery (2–3 times a week) | Yes (+) | N/S |
| $H_4$ | Food diets | No | N/S |
| | Sport activities | N/S | N/S |

N/S = Not significant.
(Source: Personal elaboration by the authors).

FWP and FWB act in the opposite way. An increase in perception corresponds with a decrease, on average, in food waste production. Previous studies [96,97] stated the importance of educational and awareness campaigns toward food waste reduction, demonstrating how positive changes in perception, in the medium and long term, affect waste behaviors. However, the advent of the COVID-19 pandemic highlighted an opposite trend, showing how human beings, placed in conditions of extreme difficulty, change habits even before perceiving their effects. Indeed, considering that all outdoor food service facilities have been limited, as well as all grocery shopping opportunities, the authors would have expected a sharp increase in food waste generation due to the sudden changes in food habits and all related negative emotions, psychological burdens [98] and stockpiling processes [53]. However, as already confirmed by previous studies [87], the so-called "stock effect" has been counterbalanced by the "I-stay-at-home effect," which helped consumers to improve households' skills, storage practices and management activities to reduce day-to-day food [52].

In terms of domestic managerial suggestions, several opportunities in the field of food waste perception and reduction are related to households' time management. Among others, considering the disruption in the agri-food supply chain, the commitment to consume food at home and the impossibility of moving beyond local borders, one possibility could concern the rediscovery of local (e.g., regional provincial) culinary habits and traditions, especially in the context of the Italian gastronomic culture. The Italian food culture has always relied on endogenous resources, products and ingredients and is based on reuse as a paradigm, combining raw materials to avoid leftovers and take advantage of seasonality, availability and zero-kilometer products. Furthermore, the increase in time allotted to domestic activities (e.g., food planning, preparation, storage) is essential to promote sustainable practices, allowing, for instance, the precise portioning of food while storing and food storage organization based on the expiration date. Indeed, the availability of previously weighted resources—in line with household needs—at the moment of storage could reduce consequential exaggerated portions, leftovers or undesirable meals. Moreover, the greater availability of time and the smart working experience enable better management in terms of food purchasing, with the consequence that it is possible to re-experience the opportunities of local markets and their related social, economic and environmental benefits.

On the side of policy implications, the active role of education must be enhanced. Indeed, the direct involvement of consumers is essential to pursue sustainable development and address climate change, but it is crucial to intervene through education, youth engagement and social innovation. As proposed by the European Commission [99], young generations and students have the potential to become ambassadors for sustainable behaviors, green consumption and environmental protection, along with ordinary citizens and families. To achieve the SDGs in general, and food waste reduction in particular, it is essential to teach

people about the sources and consequences of food waste, as well as inspire their commitment to solving the issue, developing a common attitude and correcting detrimental habits. For instance, it could be useful to implement continuous mapping and measurement of food waste quantities, drivers and disposal routes, along with introducing social and digital technologies (e.g., games, training courses, webinars) to educate and inform about criticalities, progress and future perspectives.

### 5.1. Theoretical implications, limitations and future research

Under a theoretical perspective, the present research contributes to enrich the literature on food waste perception and behavior with reference to new scenarios imposed by the pandemic (i.e., smart working, smart food delivery, novel time management), confirming past trends and adding new insights after the COVID-19 pandemic. However, it presents intrinsic limitations. First, although questionnaires are cost-effective, can be standardized and represents one of the most diffused methodologies to reach high numbers of people, they are subject both to the risk of self-selection, approximation or undervaluation by respondents. Indeed, in the absence of coaching, participants are usually unaware of the differences inherent in the concepts of perception-behavior and are somehow confused during food waste assessment [100]. Further, the snowball sampling technique, being a nonrandom methodology, has not guaranteed generalizations and is susceptible to some sampling biases (e.g., validity limitations). However, the application of the CLM to analyze four hypotheses, and the adoption of some tricks (e.g., 7-point Likert scale) to reduce possible vulnerabilities, offered robust statistical evidence, revealing interesting interconnections between changes in lifestyle during the pandemic and food waste production.

In the light of previous results and considering that young generations of students (18–25 years old) have a high likelihood to reduce food waste, the authors are intended to apply the causal research in order to verify the extent and nature of cause-and-effect relationships between new educational systems, food waste perception and food waste behavior. Indeed, the authors are interested in addressing young people to value food, highlighting their role of healthy carriers within and between generations.

## 6. Conclusions

The paper investigated the current attitudes, awareness and behavioral patterns of Italian food consumers during the COVID-19 pandemic, with particular regard to smart working, time management and smart food delivery. To sum up, the greater the time available and the greater the ability to manage it, the greater the attention paid to food waste. The pandemic period has offered people the opportunity (or has forced them) to pause, thus boosting time availability and offering opportunities to adopt diets, increase consumption of domestic products, become familiar with online shopping, improving at the same time cooking skills and domestic management practices. Indeed, always-at-home consumers decreased more likely the amount of food waste compared to partial smart workers, demonstrating the influence of time availability on better food habit planning and programming. However, the question about the future is obligatory: What will happen when the pandemic period ends? Of course, several efforts in education, food supply chain management, national and international policies, research and food consumption habits must continue to pursue the SDGs. The authors are convinced that one of the biggest challenges to reduce food waste at home, since it is not possible to donate leftovers to charities, is to educate people from an early age, for example introducing update lessons on domestic economics. It is crucial to learn today to not waste tomorrow, as well as to educate future generations on food waste hidden burdens. In a world ravaged by the COVID-19 pandemic, it is important to understand the potential for food waste reduction through local culture, education and consumer behavior. Nowadays, time is one of the most critical variables to reach the goal of sustainability.

## CRediT authorship contribution statement

Vera Amicarelli: Conceptualization, Methodology, Data Curation, Writing – review&editing, Supervision, Giovanni Lagioia: Conceptualization, Supervision, Stefania Sampietro: Methodology, Software, Formal analysis, Christian Bux: Conceptualization, Methodology, Data Curation, Software, Writing – original draft, Writing – review&editing.

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